Operations in Upper Extremity Amputees

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IN AMPUTATION of a limb, the surgical procedure is a relatively minor part of treating the patient. Before ablation the surgeon must help the patient to prepare himself mentally for the impact his loss will entail. After operation he must supervise stump conditioning. With the aid of the prosthetist and the amputee trainer (sometimes job counselor, engineer, psychiatrist or plastic surgeon) he will prescribe the prosthesis best suited to the needs of the patient and insure adequate instruction in how to use it.

Children who have had amputations of an upper extremity should be fitted with a prosthetic device early—within the first two years in most instances. Also, every effort must be made to preserve the growth centers proximal to the site of amputation. Growth in a deformed and less useful arm is invariably slower than that on the normal side. In general, it is advisable to preserve as much as possible and to postpone the operation as long as possible. Another good general rule in this connection is to permit the family (with the help of good medical advice) to decide when the time for removal has arrived.

• **The surgeon is obligated to prepare the patient mentally as well as physically for amputation. Acceptance of his loss by the patient, his family and contemporaries is important in his adjustment to his environment. He must provide the best stump possible, direct the postoperative shrinking and conditioning of the stump, prescribe the prosthetic device best suited to the needs of the individual, make sure it fits and functions, and that the patient is instructed in its maximum use.**

There are definite indications for ablation of a part. All possible length in the upper extremity should be preserved.

Amputation in children with congenital deformities should usually be postponed until demanded by the family. The growth centers should be preserved if feasible. Congenital upper extremity amputees should ordinarily be fitted within the first two years.

Neuromata, spurs, redundant tissue, scars, and phantom pain should generally be treated by other than surgical methods. Revisions, including cineplasty, should be undertaken only after careful study and when there are clear indications that benefit to patient will ensue.

SURGICAL PRINCIPLES

Prerequisites of a good amputation stump are that it have: (1) A covering of healthy, full-thickness skin without painful scars. A muscle pad about the bone, but not protruding more than ½ inch beyond the end of the bone. (2) Normal sensation. (3) Good muscle control and joint function. (4) No bony prominences or nerve endings that can be traumatized by a prosthetic device. (5) As much length as possible. One cannot always provide all these desirable features, but there must be a sufficient reason for the omission if the surgeon does not do so. The primary operation may be definitive or not, as circumstances dictate. In the presence of infection or potential infection it is usually best to do a modified guillotine amputation, with secondary closure later. In all other circumstances a single procedure, with formation of adequate skin flaps and primary closure, is done. The techniques of the various standard operative procedures will not be dwelt upon here.

SITES OF ELECTION

For many years the standard works on amputation and prosthesis of the upper extremities emphasized the necessity for making the stumps within the areas designated as "sites of election" in midarm and midforearm. Amputation through other areas was discouraged, primarily because no functional prosthetic devices were available for limbs amputated at other sites. Since the inception of the government-sponsored prosthetic research program in 1945, many new components and techniques in the fabrication, fitting and alignment of upper extremity prostheses have removed this major objection to amputation through formerly avoided regions.

Time was that transcarpal amputation, wrist disarticulation and amputation through the lower third of the forearm were not done because they necessi-

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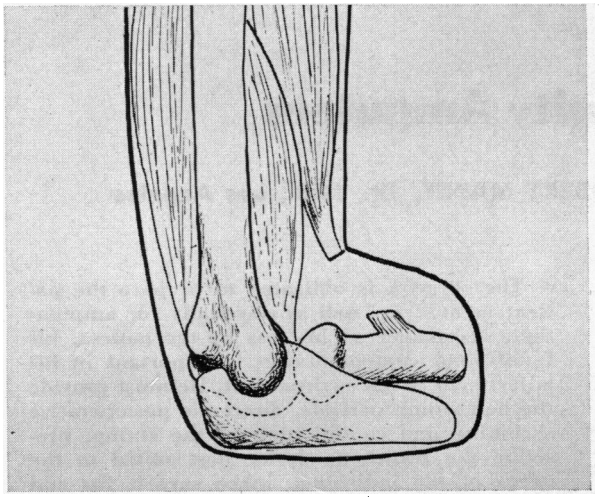

Figure 1.—Section of the insertion of the biceps tendon produces a relative increase in stump length. (By permission of J. of Bone & Joint Surg.)

tated use of a socket that would have made the arm longer than the normal opposite forearm. The wrist adaptors that are now available, however, permit fabrication of forearm sockets that obviate this undesirable asymmetry, yet make possible the preservation of wrist flexion and rotation. Preservation of the lower forearm and carpus whenever possible is also desirable. It is advisable when doing wrist disarticulations to excise the styloid process of ulna and radius. If this is not done the thin skin over these may be irritated by the socket of the prosthetic device.

The upper third of the forearm has previously been regarded as an area which could not be fitted suitably, because it was too short adequately to hold a forearm socket. The newer devices permit adequate functional fitting in this area. Blair and Morris[2] sectioned the biceps insertion in very short stumps to give a relative increase in stump length and permit higher fitting of the socket in the antecubital area for better stability and function. (Figure 1). Disarticulation through the elbow joint has been frowned upon because of the difficulty of fitting a prosthetic limb over the flaring condyles, and the necessity for a socket longer than that of the normal opposite arm. Newer techniques, the outside locking elbow joint, and the step-up elbow hinge have obviated these objections (Figure 2).

The range of function of an above-elbow prosthetic arm is directly proportional to the length, strength and the range of motion of the retained humeral lever. Preservation of as long a lever as possible is therefore desirable. Until recently, however, any stump with less than two inches of humerus distal to the axillary fold could not be fitted and harnessed functionally. It is now possible to do this. In very high arm amputations, retention of the

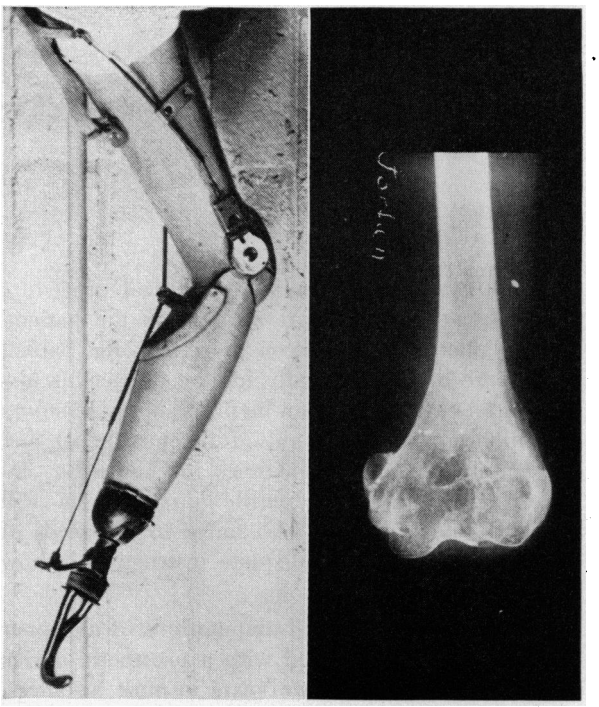

Figure 2.—On the left is the elbow disarticulation prosthesis with outside locking elbow hinge; on the right, the x-ray of the elbow disarticulation. (By permission of J. of Bone & Joint Surg.)

head of the humerus is desirable for cosmetic reasons, and because it permits a firmer grip of prosthesis on shoulder girdle, thereby increasing security and minimizing rotation of prosthesis about the shoulder.

The successful fitting of many persons who had amputations through the so-called undesirable areas with appliances and techniques developed in recent years, has demonstrated that the concept of "sites of election" in upper extremity amputations is obsolete.[5,7] Amputation operations on an upper extremity should be directed toward saving all possible length in all areas. Prosthetic consideration need not dictate an amputation site. Physical factors, such as skin coverage, adequacy of circulation, good innervation, and function of the part to be saved should be the determining factors in deciding the level of amputations (Chart 1).

Secondary closure is necessary when amputation of the guillotine type is used. It is occasionally necessary to trim off bony prominences or redundant soft tissue in order to form a better stump. Bony prominences such as the anterior crest of tibia are easily irritated by a prosthetic socket. Rarely is redundant soft tissue an indication for revision, for allowance can be made for it when tailoring the socket. Long-standing, persistent drainage and failure of the wound to close, however, are reason for excision of infected tissue secondarily.

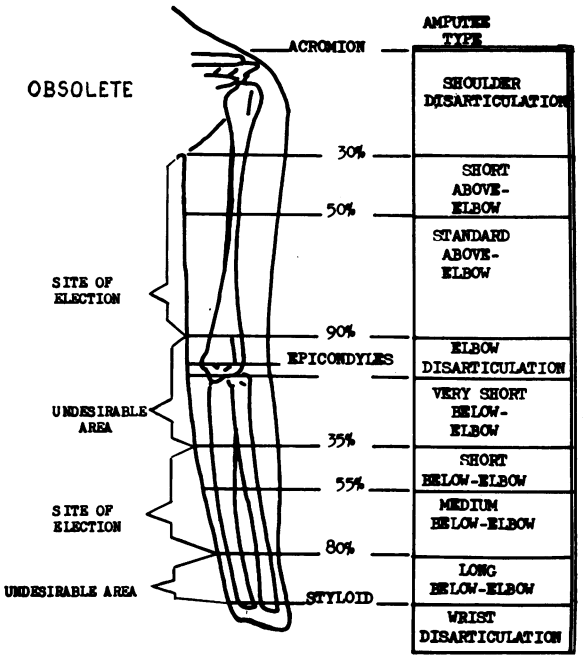

Chart 1.—On the left, the old "sites of election" and "undesirable areas" are shown. On the right, prosthetic designations for amputations at various levels.

CINEPLASTY

Since the second world war, there has been a revival of interest in ways to activate prosthetic devices by contraction of a skin-lined muscle tunnel. A number of studies have been made of the efficacy of cineplasty, and they have shown rather conclusively that this operation is of value in only a few amputees. Brav[3] reviewed 78 cases of cineplastic operations on biceps and 29 on pectoral muscles and found 70 per cent of the biceps tunnels and 35 per cent of the pectoral tunnels "successful." In the author's[8] series, 19 of 27 or 70 per cent of biceps tunnels gave satisfactory use and service to the amputee, as did 6 of 12 or 50 per cent of pectoral tunnels. Of two triceps and 15 forearm tunnels, none functioned. Except in very rare circumstances, therefore, only the biceps cineplasty in below-elbow stumps is worthwhile.

The advantages of biceps cineplasty are: (1) There is greater range of motion of the prosthesis; (2) the axilla loop used in harnessing of a standard prosthesis is not needed; (3) deep proprioceptive sensation is restored, which enables the amputee to "feel" the location of the terminal device; (4) there is improved performance of fine hook or finger motion.

Patients should be carefully selected for cineplasty. They should be mature, well adjusted, persevering and well motivated persons who will cooperate in learning to use the prosthetic device. They should have seen others who have had cineplasty and they should want the operation. They should have done well with a conventional prosthesis for at least six months.

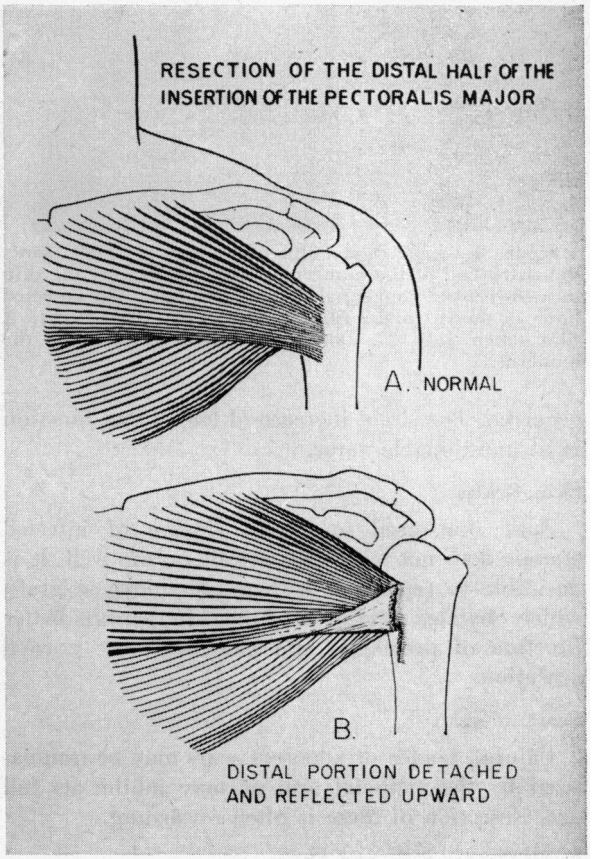

Figure 3.—Reflection of the lower half of the insertion of the pectoralis major produces a relative increase in stump length. (By permission of the J. of Bone & Joint Surg.)

Stump Lengthening

There are two types of stump in which efforts to increase length may be justified:

1. A well-formed but very short below-elbow or above-elbow with good sensation and muscle power, in which fitting, or function or both could be improved by additional length. In these instances, provided the patient understands his problems, wants to be a good prosthetic user, and does not expect too much from the operation, section of the biceps insertion into the radius, or reflection of the insertion of the pectoralis major[8] into the humerus, will provide some increase of relative length and function. (See Figure 3.)

2. In stumps with good skin and muscle power, where the humerus is considerably shorter than the redundant soft tissue hanging from it. Implantation of a fibular graft into the end of the humerus has been attempted in a few instances.[12,13] In these cases resorption of much of the transplant has

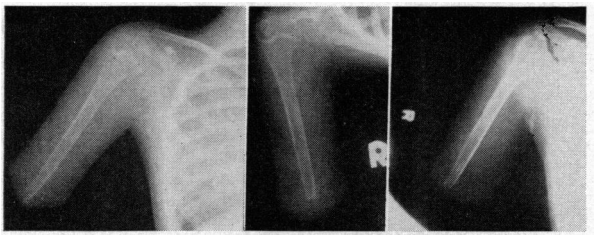

Figure 4.—*Left:* X-ray film taken May 25, 1959, shows the sharp end of the humerus almost penetrating the skin in a 10-year-old congenital amputee. *Center:* The resected bone is shown in the film of August 21, 1959. *Right:* A film taken July 27, 1960, shows re-overgrowth of the humerus.

occurred. The slight increase of length and function is of questionable value.

Skin Grafts

Split skin used to obtain closure of infected stumps does not withstand prosthetic use well. It is desirable to replace it with a full thickness graft, which obviates ulceration of the skin, permits better function of prosthesis and provides more normal sensation.

Scars

Painful, tender or adherent scars may be traumatized by the artificial arm or may inhibit its full use. Resection of these is often rewarding.

Bony Overgrowth and Spurs

In children, the humerus and the tibia may grow faster than the surrounding soft tissue, stretching it and bringing about ulceration through the stump end. This may occur even in congenital cases. Shortening of the overgrown bone is necessary[4] and may have to be done more than once if overgrowth recurs (Figure 4). Spurs practically never cause enough trouble in upper extremity amputees to necessitate removing them.

Neuromata

Too many operations are done for "removal of neuromata." It is not unusual for a high-strung or hypersensitive amputee to have pain which he relates to the cut end of a nerve trunk. The area may be tender. Usually in such cases, excision of the neuroma is followed by a couple of months' relief from pain. Then the patient's boss takes him to task for something, or his wife wants a new fur coat, and the pain returns, being now referred to another nerve end or to the same nerve higher up. Resection of neuromata rarely results in permanent relief. Local procaine injection, application of heat or cold, sometimes intravenous pentothal or procaine, may help. Psychiatric evaluation is usually indicated.[6] In children a significant number of painful neuromata, uncomplicated by psychic problems, have been removed with good relief.[1]

PHANTOM PAIN

Phantom pain is not a problem in congenital amputees or those who have had traumatic amputation in the first decade of life. Traumatic amputations during the second decade may be followed by phantom sensation, but almost never pain. In adults, phantom sensation is practically universal, pain fortunately rare. The pain studies by the Amputee Research Group at the University of California, Berkeley, have elucidated some instructive facts.[11]

Phantom pain manifests itself in a variety of ways. The missing part frequently moves into a more proximal location than it normally inhabits. The painful sensations may take the form of burning pain or the feeling of having red hot pins stuck into it. The toes or heel may feel as though squeezed in a vice, struck by a hammer or twisted into a grotesque deformed shape, or there may be agonizing muscle cramps. There may be only a tingling of finger or toe.

Approximately 30 per cent of amputees have no phantom pain. In about 5 per cent it is very severe.

Treatment is as has been outlined under neuromata.

Re-amputation is futile.

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